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REPORT UPON THE BLACK AND BOGGY SWAMPS DRAINAGE DISTRICT, HAMPTON AND JASPER COUNTIES, S. C.

By F. G. Eason, *Drainage Engineer.*

INTRODUCTION.

While in some respects all the swamp lands of the Atlantic Coastal Plain are alike, the problems to be met in draining the lands differ somewhat from one section to another. In Georgia and the Carolinas are many areas that have little slope as a whole, but in detail are somewhat rolling. From the higher parts, scattered among the flat open woodlands and the timbered bays and branches in which water stands the greater part of the year, the timber has been cleared and small farms have been established. The watercourses, which are broad, shallow, winding depressions, with no marked channel, are usually filled with growing timber and thick underbrush.

The topographical conditions require that these lands be drained in units of considerable size, necessitating the cooperation of many landowners. In order that a few owners may not prevent a greater number from reclaiming their wet lands, when the few can not be excluded from the district to be formed, most States have passed general laws providing for the organization of drainage districts and an equitable distribution of the cost. In accordance with such a statute enacted in 1911 by the Legislature of South Carolina, the Black and Boggy Swamps drainage district was organized in March, 1912.

Because the Black and Boggy Swamps drainage district is in many respects typical of other areas in the same and bordering States, and because it is the first district organized under the above law, and as the landowners are naturally cautious about beginning an unfamiliar kind of undertaking, Drainage Investigations of the Office of Experiment Stations, United States Department of Agriculture, at the request of the landowners and in cooperation with them, made a

Note.—This paper is intended for engineers and others interested in drainage enterprises in regions where the conditions are similar to those here described; it is suitable for distribution in the South Atlantic States.

survey of the district and prepared plans of the work to be done, together with an estimate of the cost. The survey was begun in August, 1912, and field work was completed in November of the same year. The following report presents a description of the district and of the drainage plan and a brief discussion of the problems involved in such reclamation.

GENERAL DESCRIPTION.

LOCATION.

Black and Boggy Swamps drainage district is located about 75 miles west of Charleston, S. C., 40 miles north of Savannah, Ga., and 100 miles south of Columbia, S. C., in the southern part of Hampton County and the western part of Jasper County, S. C. (See fig. 1.) It includes all the lands drained by Boggy Swamp and Black Swamp, together with the lands in the vicinity of Garnett that are drained by Church Branch, Hog Branch, and King Branch, all extending as far down as high water from the Savannah River; the area is 67,642 acres, or about 106 square miles. In shape the district is approximately a rectangle, 12 miles long northwest and southeast, and 9 miles wide. The Seaboard Air Line Railway and the Columbia-Savannah line of the Southern Railway traverse the district in a northerly and southerly direction, and on these railroads are situated the principal towns in the district, Scotia, Garnett, Furman, and Pineland. Other towns and settlements in the district are Brighton, Shirley, Robertville, Lawtonville, Staffords, and Goethe.

TOPOGRAPHY.

The district is situated 40 to 50 miles from the Atlantic Ocean, and thus lies within the Coastal Plain. There are in the neighborhood, including the Black and Boggy Swamps district, three distinct benches or levels paralleling the Savannah River. First, the river swamp proper; second, a higher level subject to occasional overflow, known locally as "savannas"; and third, the general elevation of lands in the district under consideration. The north, east, and west boundaries of the district are formed by natural watershed lines, but no such natural boundary occurs on the south. The general elevation of the lands in the southern part of the district east of the Seaboard Air Line Railway varies from 50 to 70 feet above sea level until the second bench from the river is reached, where it suddenly falls off about 25 feet. The foot of this slope has been determined upon as the district boundary. The southern part of the district west of the Seaboard Air Line Railway is much flatter and no decided slope is evident, the land rising gradually from the second to the third level, so that the southern boundary of the district should be more accu-

rately established than has yet been done. It should be the limit of high water from the Savannah River.

The general slope of the ground is southward toward the coast and westward toward the Savannah River, which is the outlet for all of

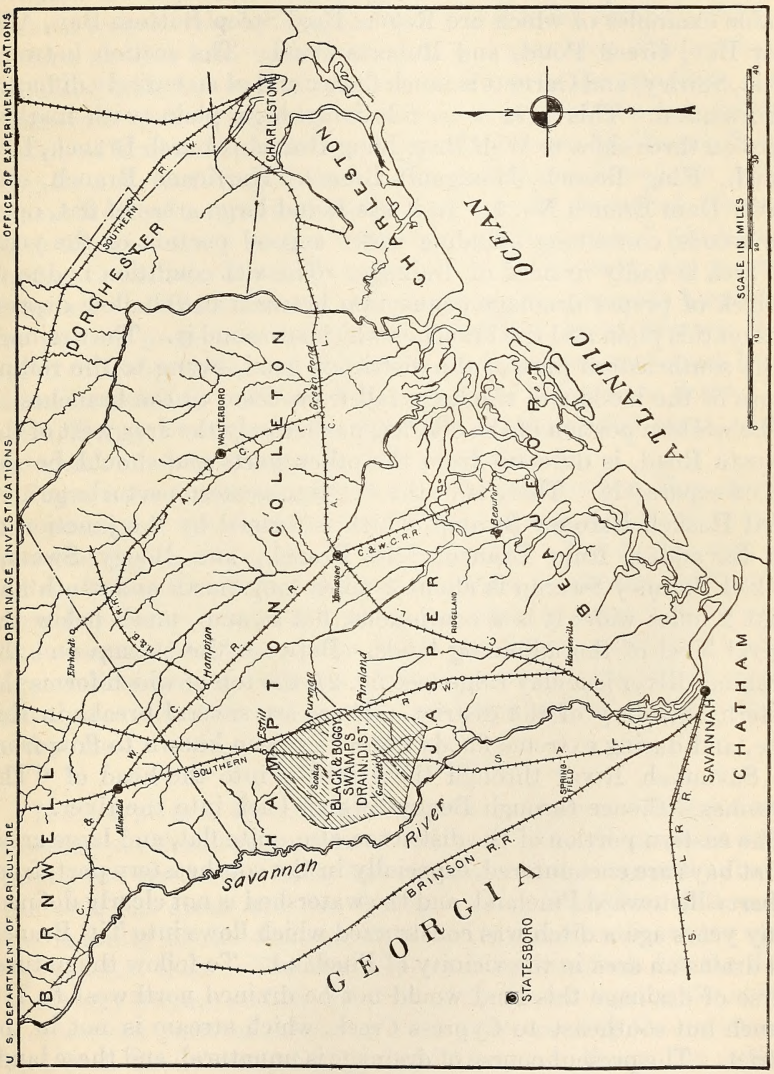


FIG. 1.—Map showing location of Black and Boggy Swamps drainage district.

the drainage of the district. The northern or upper end of the district is much more rolling and hilly than are the southern and western ends. The topography north of Shirley, Scotia, and Furman (see fig. 2) is very irregular, there being considerable stretches of high land now under cultivation, broken by large areas of flat bays and swamps

of much lower elevation. These bays usually are the headwaters of the various branches which flow southerly through the district. Practically all of the land in the upper section of the district that can be cultivated under present conditions is now being farmed; the remainder is composed almost entirely of these flat bays and branches, notable examples of which are Rogers Bay, Steep Bottom Bay, Alligator Bay, Green Pond, and Roberts Pond. The section between Scotia, Shirley, and Garnett is much flatter and of an entirely different conformation. This area is a relatively high plain, with marked slopes on three sides to Wolf Bay, Long Branch, Church Branch, Hog Branch, King Branch, Manigault Branch, Hurricane Branch, and Beaver Dam Branch No. 1. In it are found large areas of flat, open pine woods, containing standing water a good portion of the year. The area is badly in need of drainage. The wet condition is due to the lack of proper drainage connection between the shallow depressions on this plain and the branches which surround it. The drainage in the southeastern part of the district is good, owing to the rolling nature of the lands and the large fall from them to the branches.

The western portion of the district, particularly the area west of the Augusta Road, is different from the other parts and should be described separately. There is in the extreme western part a large area called Haskell Baroney Swamp, which is formed by the junction of The Savannas, Rum Branch, Mill Branch, and Boggy Swamp. Haskell Baroney Swamp is about 3 miles long north and south and about 2 miles wide; it is a continuous, flat swamp, much below the general level of the adjoining lands. Between the swamp and the Savannah River is a clay ridge (see fig. 2), the top of which forms the western boundary of the district. There are several breaks in this ridge, and during extreme floods water has been known to flow from the Savannah River through these breaks into the head of "The Savannas," thence through Boggy Swamp back into the river.

The eastern portion of the district is also quite flat, and large areas of flat bays are encountered, especially in the southeastern part, from Robertville toward Pineland, and the watershed is not clearly defined. Many years ago a ditch was constructed which flows into Titi Branch and drains an area in the vicinity of Pineland. To follow the natural course of drainage this land would not be drained northwest to Titi Branch but southeast to Cypress Creek, which stream is not in the district. The present course of drainage is unnatural, and these lands have therefore been excluded from the district.

There are several ponds in the district which, owing to their depth, can not be drained by gravity, but must remain undrained unless pumping is resorted to. The general location of these ponds is the flat land between Scotia and Shirley, but the total area is only a few acres.

The highways of the district are the usual dirt roads, but they have been improved recently by the county and are now in very good condition.

WATERSHEDS.

There are two distinct primary watershed areas in this district, drained respectively by Boggy Swamp and Black Swamp, which are in turn divided into various secondary watersheds drained by the tributary branches or swamps. In addition to the two main watersheds with their tributaries there is included within the district a section of land in the vicinity of Garnett drained by Church Branch, Hog Branch, and King Branch. These branches flow down into the second level of overflowed lands bordering the Savannah River and form what is known as the "Pallachucolla Savannas," which empty farther down into Black Swamp. Thus, while they are in reality tributaries of Black Swamp, they will require separate handling so far as this project is concerned. Similarly, Scott Swamp No. 1, south of Robertville, and two small areas farther west must be considered separately. Black Swamp and its tributaries drain 18,490 acres, Boggy Swamp and its tributaries drain 36,693 acres, and the independent watercourses drain 12,459 acres.

These watershed areas are for the most part fairly rolling, although the portion of the district west of the Augusta Road and that part between Scotia and Garnett are quite flat. The higher and more rolling lands are cultivated to some extent at present, as they have very fair natural drainage, which is aided by some farm drainage; but even on those lands crops fail in wet years, showing the need of a general system of drainage. The swamps and the flatter areas are mostly covered with timber, which is being rapidly cut off by lumber companies.

DRAINAGE CHANNELS.

There is no lack of drainage channels in Black and Boggy Swamps district, yet drainage conditions are bad. The situation is due primarily to two causes—(1) lack of suitable drainage connection between the wet, flat areas and the drainage channels or branches, and (2) the inability of the drainage channels to remove the water after it has reached them. The two main drainage channels for the district are Boggy Swamp and Black Swamp, the former serving the northern and western parts of the district, the latter serving the eastern part, and both finally emptying into the Savannah River, the outlet for all of the water from this district. There are numerous smaller branches or swamps tributary to these, which reach out to the different parts of the district, and which are the outlets for the drainage from their respective watersheds. A general description of these channels will suffice for this discussion, since they are all similar in character and differ only as to size.

In general, the drainage outlets are low, flat branches or swamps, varying in width from 50 to 1,500 feet and having in most instances no discernible channel or "run." Where a branch has a run of appreciable size, the latter will almost invariably be found so choked with fallen logs and trees, bushes, and all manner of débris, as to afford but a poor channel for the water. The branches are overgrown with thick underbrush and water-loving trees, such as cypress, gum, maple, and ash, through which the water finds its way but slowly There being in most places no channel, the water covers the ground from hill to hill, and the swamps, therefore, can not be cultivated. Where the adjoining land lies but little above the level of the swamp it also is affected to a great extent by this water, which seeps the land and thus keeps it wet and sour. While cleaning out these swamps would undoubtedly help conditions considerably, this alone will not give satisfactory drainage, which can result only from lowering the water table by the construction of deep ditches. These swamps are almost continually wet, and in most seasons contain standing water. However, with the exception of those near the Savannah River, they all have large fall and can easily be drained. The bays and ponds where most of these branches have their rise are very flat, and for this reason will be much more difficult to drain.

In places throughout the district ditches have been dug in these branches, and much good has resulted from them. Hurricane Branch and Hog Branch have been improved in this manner, and little additional work on them is necessary, the swamp often being under cultivation right up to the edge of the ditch. These are exceptions, however, and comparatively little work of this character has been done. After having been constructed, these ditches have not always been maintained, and consequently have filled up and fallen into disuse.

SOIL AND CROPS.

The predominating soil of the district is a light sandy loam underlain by a reddish to yellow clay subsoil at depths of 4 to 18 inches. This is the type most generally cultivated in the district at this time. The soil on the flat "piney woods" land is composed of a grayish clay, which is extremely tenacious and is difficult to drain on account of its compact nature. Toward the Savannah River the sandy soil changes to a red clay, which can be seen outcropping in places. The soil of the bays, swamps, and branches is a heavy black muck, several feet thick, which in most places is underlain by a clay, but in some of the bays by a sandy subsoil. While the ditches planned are to be located almost entirely in the muck soil of the swamps and branches, they are to furnish drainage outlets for all the district, as all the soil types need drainage, though the need is not so great for the loam soil as for the others.

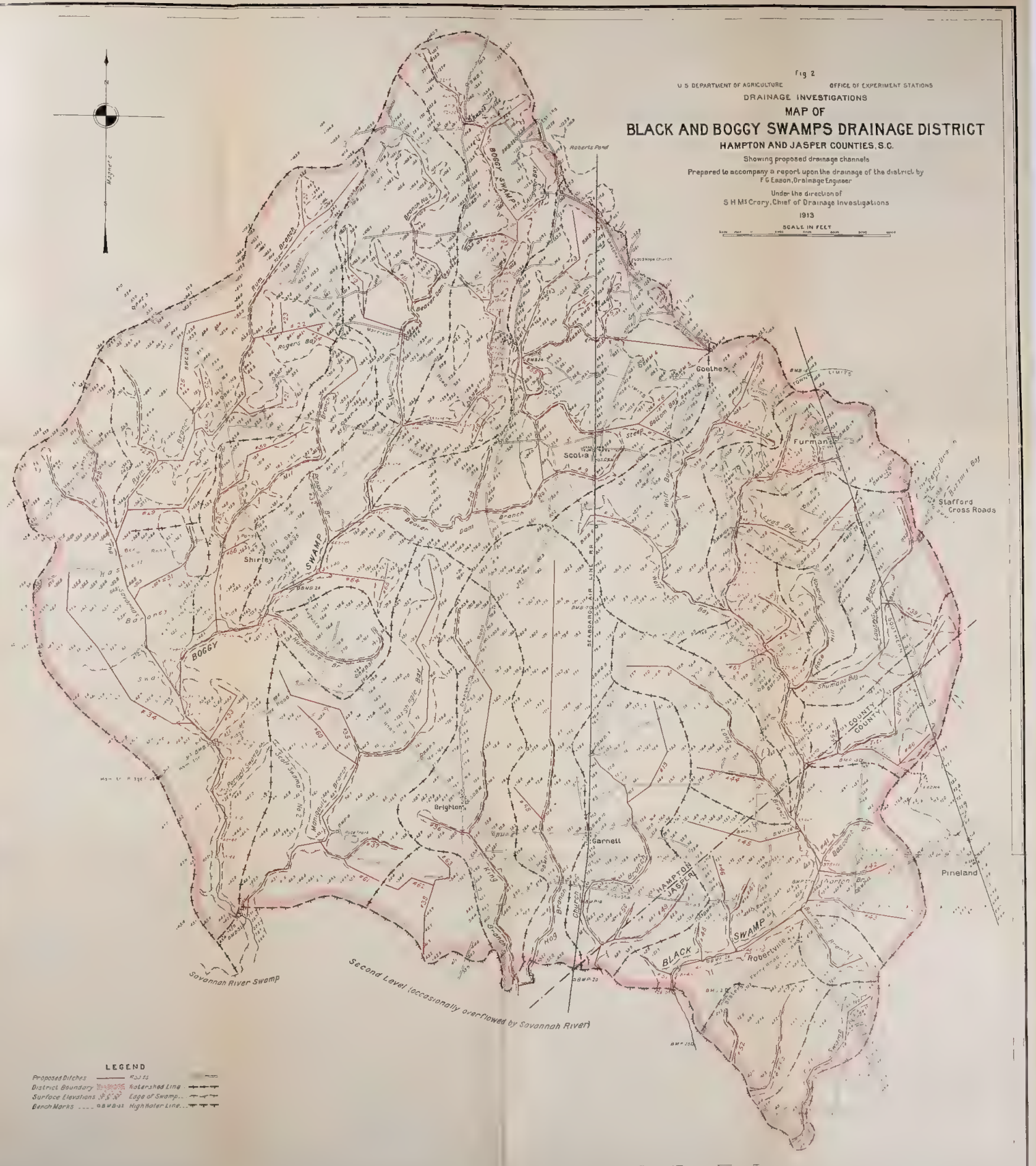
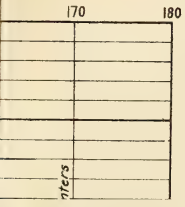


Fig 2
U S DEPARTMENT OF AGRICULTURE
OFFICE OF EXPERIMENT STATIONS
DRAINAGE INVESTIGATIONS
MAP OF
BLACK AND BOGGY SWAMPS DRAINAGE DISTRICT
HAMPTON AND JASPER COUNTIES, S.C.
Showing proposed drainage channels
Prepared to accompany a report upon the drainage of the district by
F G Eason, Drainage Engineer
Under the direction of
S H McCrory, Chief of Drainage Investigations
1913
SCALE IN FEET
Magnetic
Roberts Pond
Coelhe
Furman
Scotia
Starford Cross Roads
Shirley
BOGGY SWAMP
SEABOARD AIR LINE R.R.
Brighton
Garnett
Pineland
Robertville
HAMPTON JASPER
BLACK SWAMP
Savannah River Swamp
Second Level (occasionally overflowed by Savannah River)
LEGEND
Proposed Ditches
District Boundary
Surface Elevations
Bench Marks
Roads
Watershed Line
Edge of Swamp
High Water Line


170
180

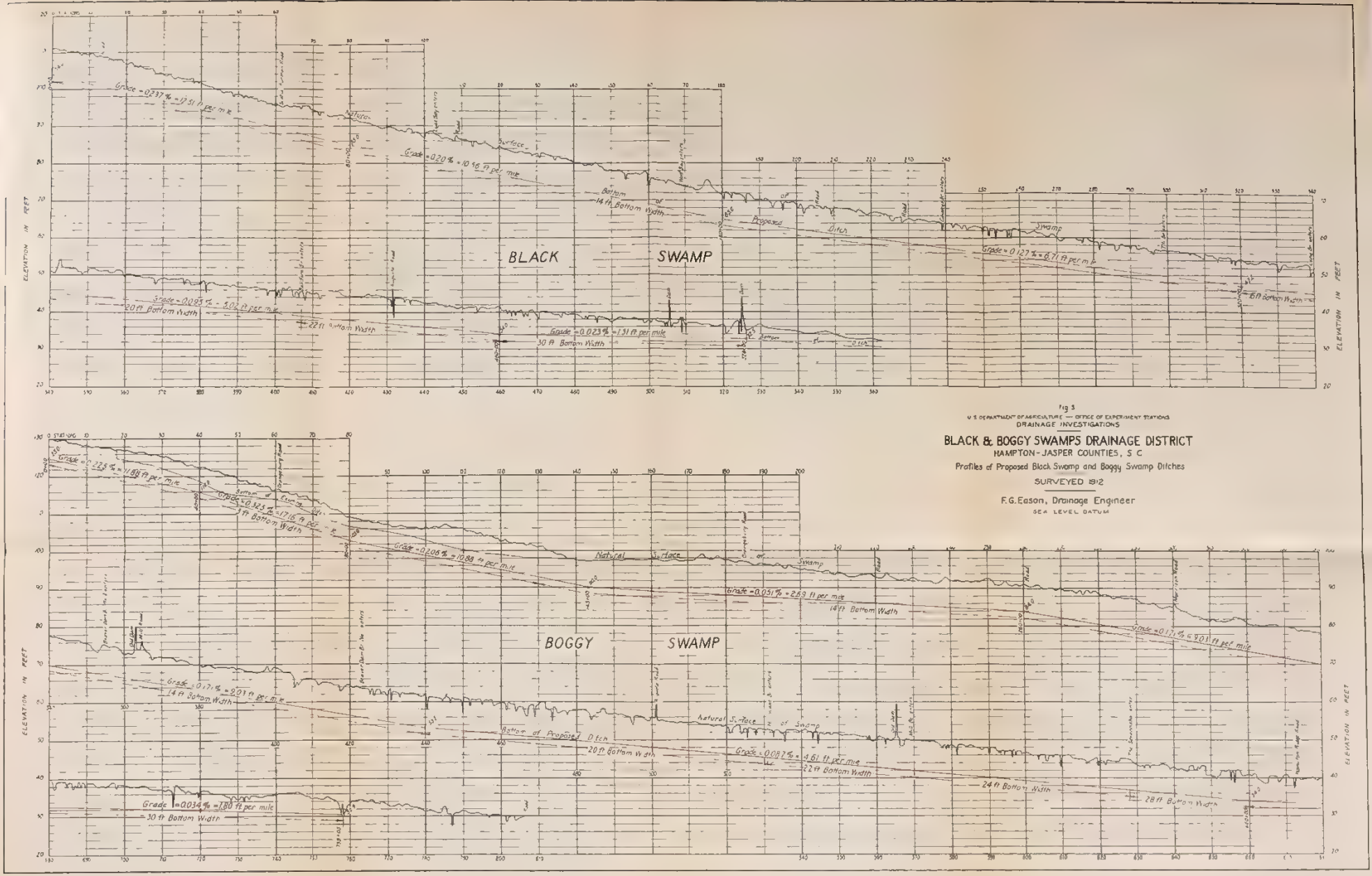

BLACK SWAMP
BOGGY SWAMP
ELEVATION IN FEET
Grade = 0.237 % = 12.51 ft per mile
Grade = 0.20 % = 10.56 ft per mile
Grade = 0.095 % = 5.02 ft per mile
20 ft Bottom Width
22 ft Bottom Width
Grade = 0.023 % = 1.21 ft per mile
30 ft Bottom Width
Bottom of Proposed Ditch
14 ft Bottom Width
Natural Surface of Swamp
Grade = 0.127 % = 6.71 ft per mile
Grade = 0.225 % = 11.88 ft per mile
Grade = 0.323 % = 17.06 ft per mile
3 ft Bottom Width
Grade = 0.206 % = 10.88 ft per mile
Grade = 0.051 % = 2.69 ft per mile
14 ft Bottom Width
Grade = 0.171 % = 9.01 ft per mile
Grade = 0.171 % = 9.01 ft per mile
14 ft Bottom Width
Bottom of Proposed Ditch
20 ft Bottom Width
Grade = 0.087 % = 4.61 ft per mile
22 ft Bottom Width
24 ft Bottom Width
28 ft Bottom Width
Grade = 0.034 % = 1.80 ft per mile
30 ft Bottom Width

Fig 3

U S DEPARTMENT OF AGRICULTURE — OFFICE OF EXPERIMENT STATIONS

DRAINAGE INVESTIGATIONS

BLACK & BOGGY SWAMPS DRAINAGE DISTRICT

HAMPTON - JASPER COUNTIES, S C

Profiles of Proposed Black Swamp and Boggy Swamp Ditches

SURVEYED 1912

F.G. Eason, Drainage Engineer

SEA LEVEL DATUM

The principal industry of the people of the district is farming; but only a small part of the land available for this purpose is now being utilized, due to the sparsely settled condition. The chief money crop of the district is cotton, and the greater part of the acreage under cultivation is planted to it. The other crops grown are principally corn, oats, hay, and watermelons. Labor conditions in the district are not of the best, but notwithstanding this drawback very good crops are obtained, due to intelligent methods of cultivation and fertilizing. The growing of truck crops might become very profitable by the utilization of artesian water for irrigation. There are already a number of these wells scattered over the district, all of which are bold, flowing wells from 900 to 1,000 feet deep.

THE SURVEY.

The survey was made from camp by a party under the direction of F. G. Eason. Field work was begun August 2, 1912, and completed November 14, 1912. The principal roads of the district were traversed by compass and stadia, ground surface elevations being taken at intervals of about 500 feet. All the branches, swamps, and watercourses were meandered by stadia and compass, and sufficient elevations were taken in them to secure the data necessary for the proper location of the ditches. Levels were run entirely across the district, usually east and west, at intervals of about one-half mile, and these lines were tied to all other level lines crossed. Levels were also run along both railroads.

After the edges of Boggy Swamp and Black Swamp had been surveyed, the locations of the proposed ditches in them were determined by means of compass and steel-tape measurements, except from station 0 to station 150 on Boggy Swamp and from station 0 to station 62 on Black Swamp. On the located lines stakes properly marked were set at intervals of 100 feet; substantial hubs were set about 500 feet apart and at angles in the line; and the trees along the lines were well blazed. Profile levels were run over these lines, elevations being taken every 100 feet. The Black Swamp and Boggy Swamp ditches were the only ones located in the field; the other ditch lines shown on the map were not surveyed.

The datum for the levels is sea level as secured from the Seaboard Air Line Railway, taking the elevation of top of rail at Scotia and running all levels from that point. Bench marks were set along the main roads and at other prominent points, usually on roots of trees suitably inscribed. Three standard iron and bronze Drainage Investigations bench marks were set, one each at Scotia, Brighton, and Robertville. The data secured in the survey are shown on the accompanying map and profile (figs. 2 and 3).

RUN-OFF.

The "run-off" from a natural drainage basin is generally understood to be that water which flows from the area through the surface outlet channel. In designing drainage improvements, consideration must be given to the maximum rate of run-off for which provision should be made rather than to the total quantity to be removed. The principal factors affecting this rate in the Black and Boggy Swamps drainage district are rainfall, soil, and topography.

RAINFALL.

There are no stations of the United States Weather Bureau within this district, although it is well surrounded by stations at which continuous precipitation records have been kept for years. From a study of the records secured at Allendale, Walterboro, and Yemassee, S. C., and Statesboro, Ga. (see fig. 1), the rainfall in the Black and Boggy Swamps district can be learned with sufficient accuracy. These daily records for the years 1903 to 1912, inclusive, have been carefully compared with each other and with the daily records secured at Whiteville, N. C., for comparing this district with the Chadbourn and Lyon Swamp districts as explained in the following paragraphs.

PROBABLE RATE OF RUN-OFF.

Drainage districts where conditions are similar to those in the Black and Boggy Swamps drainage district have been completed in southeastern North Carolina and have been in operation for sometime, but no measurements of flood run-off from these ditches have been made. These districts, however, afford the best guide in designing the ditches for this district. At Chadbourn, N. C., the rainfall, topography, evaporation and transpiration of plants, climate and seasons, the natural reservoir and storage capacities of the streams, and the nature of the vegetable growth are very nearly the same as in the district under discussion. Several ditches which drain areas varying in size from 400 to 2,150 acres have been constructed in that locality and have been in operation for about two years. The principal difference between conditions at Chadbourn and in Black and Boggy Swamps district is that the soil at Chadbourn is a sandy loam 3 to 8 inches deep underlain by a clay or clayey sand that is quite permeable and which will absorb water very readily; this, as compared with the soil in the district under discussion, will give a low run-off. The ditches at Chadbourn were designed to remove 1 inch in depth of water from the entire watershed in 24 hours when running bank full. Where those ditches were constructed as designed they are working satisfactorily.

In Bladen and Pender Counties, N. C., the Lyon Swamp Canal, which drains an area of about 18,000 acres, has been completed for a

year or more. Conditions in the Lyon Swamp district are practically the same as at Chadbourn, and the chief difference, so far as run-off factors are concerned, between that district and the Black and Boggy Swamps drainage district lies in the character of the soil. The drainage area of the Lyon Swamp district consists of 6,000 acres of dark brown and black loam from 3 to 5 feet deep underlain by a coarse sand, which gradually changes to a fine sand, and about 12,000 acres of sand ridges and bays, the latter varying in size from 1 acre to 2,000 acres. The soil of the sand ridges consists of a very coarse white sand, which absorbs the heaviest rainfalls with great rapidity. That of the bays consists of a very fine white sand near the surface, which also absorbs water quite readily. The entire area is underlain by blue marl at a depth of from 15 to 20 feet below the surface. The Lyon Swamp ditch was designed to remove one-half inch in depth of water from the entire area in 24 hours. The soil in this district, taken as a whole, will give a considerably lower run-off than that of the Black and Boggy Swamps drainage district.

From the preceding description of the several districts it will be seen that the chief difference is in the character of the soil, that of the Black and Boggy Swamps drainage district being of such a character as to give a somewhat higher run-off than either of the other districts. Therefore it would appear that the main outlet ditch for Boggy Swamp should be designed to remove a run-off of three-fourths inch depth in 24 hours from its entire watershed of 36,693 acres and 1 inch depth from areas less than 20,000 acres. On the same basis the main outlet ditch for Black Swamp should be designed to remove 1 inch of depth of run-off from its entire watershed area, 18,490 acres.

PLAN OF IMPROVEMENT.

The plan recommended for reclaiming the lands of Black and Boggy Swamps drainage district consists of a system of open ditches. These ditches, as a general rule, are planned to lie in the lowest parts of the swamps and are as straight as can be made without leaving the swamp. In only a few instances have the swamps been departed from, the object in these cases being to make cut-offs across the adjoining lands where they are low, thus reducing the distance. The complete plan involves the construction of 68 miles of dredged ditches and 98 miles of handmade ditches, a total of 166 miles for the district. On the two lines located in the field all changes of direction have been shown by angles, which in construction should be replaced by curves of suitable radius so that the flow of water will not be retarded by abrupt changes of direction. In the following paragraphs some of the principal features of ditch construction as applicable to this district are taken up.

SIZES OF DITCHES.

The computations of the ditch capacities have been based on the Chezy formula for flow in open channels, $V = C\sqrt{RS}$, in which C was determined by Kutter's formula, using 0.030 as the value of the roughness coefficient "n." Except at the lower end of Boggy Swamp and Black Swamp, however, the controlling feature in determining the sizes of the ditches has been the method of construction rather than the required capacity of the waterway.

Experience has shown that in heavily timbered lands such as these the best type of machine to use is the floating dipper dredge; but to float a machine of this kind frequently requires a larger ditch than would be necessary to take care of the maximum run-off. In lieu of the dredge the only practicable methods of construction will be hand labor or explosives; by the former method a ditch of just the required size could be constructed, but at a price per cubic yard very much greater than for dredge work, so a ditch roughly two and one half times the required size, provided it is no smaller than the minimum dredge ditch, could be constructed by the dredge for the same cost as by hand labor and in a much shorter time. The construction of ditches with explosives is comparatively new, and has met with varying degrees of success. It might be well to experiment with this method on some of the smaller ditches, which are of a size best adapted to its use.

The smallest ditch that can be constructed with a dipper dredge of sufficient power to remove the stumps and sunken timbers is one with a 14-foot bottom width, 6-foot depth, and side slopes ½ horizontal to 1 vertical. Such a ditch would have a top width of 20 feet. However, to afford proper drainage the depths of the dredged ditches should in this case be not less than 7 feet, and therefore wherever in this report the phrase "minimum dredge ditch" is used it refers to a ditch with 14-foot bottom width, 7-foot depth, and ½ to 1 side slopes. Ditches of this character are proposed for all of the main tributary branches except Hurricane Branch, Scott Swamp No. 1, Ballifore Branch, Rose Hill Branch, Titi Branch, Causeys Branch, Long Branch, and Lyas Bay, which streams are too short to warrant putting in a dredge. On some of the tributaries the upper mile of each ditch should be excavated by hand, as such channels will have sufficient capacity and will cost considerably less than minimum dredge ditches. The ditches to be constructed by hand labor, with one exception, are recommended to have 3-foot bottom widths, 5-foot depths, and ½ to 1 side slopes; such a ditch has an 8-foot top width. This kind of ditch will be referred to in this report as a "handmade ditch," as all of the ditches not constructed with dredges are recommended to be of this size except the upper end of Boggy Swamp, which should be 6 feet deep. The excavation for a minimum

dredge ditch is 4.54 cubic yards per linear foot of channel, and for a handmade ditch it is approximately 1 cubic yard per foot.

BERMS.

In order not to put undue weight on the ditch banks and to keep the waste material from refilling the ditches, a clear berm of 8 feet between the edge of the ditch and the toe of the spoil bank should be left on each side of all the dredged channels, and similar berms 3 feet wide should be left along the handmade ditches.

RIGHT OF WAY.

It is necessary that a right of way be cleared through the swamps for all the ditches and that it be purchased and owned by the drainage district. The width of the right of way should be determined according to the bottom width of the ditch, since the depth of cut does not vary greatly, as follows: For 3-foot ditch, 30-foot right of way; for 14-foot ditch, 80-foot right of way; for 16 to 20 foot ditch, 90-foot right of way; for 22-foot ditch, 100-foot right of way; and for 28 to 30 foot ditch, 120-foot right of way. The improvements recommended in this report will require a total of 1,043 acres right of way.

It is suggested that an effort be made to secure easements for the right of way instead of purchasing it, as has been done by some drainage districts. Such easements give the district complete control of the land so long as it is used for drainage works; otherwise the land reverts to the owner.

BRIDGES.

The State law requires that the drainage district construct all public highway bridges that are made necessary by the construction of a ditch. Steel bridges with concrete abutments are recommended, although costing more than wooden structures, because the cost of maintenance will be much less. In making the estimate of cost, bridges have been included for all public road crossings. It is assumed that in most cases 30-foot bridges will be suitable for ditches with 14-foot bases, and 15-foot bridges for ditches with 3-foot bases.

IMPROVEMENTS IN BOGGY SWAMP WATERSHED.

Boggy Swamp is the longest stream in the district, and drains the largest area. The swamp along the upper 2½ miles of this stream is not over 100 feet wide; then it increases to about one-half mile wide, continuing so to the Orangeburg Road. From there to the Morrison Road it narrows to as little as 50 feet in places, having occasional arms or branching bays. Between Morrison Road and Haskell Baroney Swamp the width varies from 200 to 1,500 feet, averaging

about 500, and from a mile above Hamilton Ridge Road to the river swamp the width is about 700 feet. The upper part of the drainage area is comparatively well drained, and largely under cultivation. It is rolling, with good fall to the swamp. Below the Orangeburg Road the land is much flatter, with little fall to the swamp above the Morrison Road, but with a break of 10 to 25 feet to the swamp level below that road. The largest cultivated tracts are along the main swamps where drainage is better than on higher land farther back. The chief need of this section is better drainage channels to bring the water to the main streams.

The proposed improvement in Boggy Swamp consists of a ditch throughout the length of the swamp. (See figs. 2 and 3.) From station 0, the upper end, to station 130, the ditch should be constructed by hand labor, with 3-foot bottom width, 6-foot depth, and side slopes ½ to 1, giving a top width of 9 feet. From station 130 to station 758, the lower end, the ditch is to be constructed with a floating dipper dredge. At the upper end of this portion there will be a minimum dredge ditch, and the bottom width will gradually increase to 30 feet at the lower end. The total fall in Boggy Swamp is 100 feet, varying from 17 feet per mile at the upper end, to 1.8 feet per mile at the lower end. (See fig. 3.) The Boggy Swamp ditch is not carried on to the Savannah River Swamp, but ends about 1½ miles below the Hamilton Ridge Road. Below the end of the proposed ditch the water will overflow the swamp, but the lands adjoining this portion of the swamp are much higher and will not be damaged, while the swamp itself is subject to overflow from the Savannah River and will be of little value for agriculture.

The following table summarizes the data and hydraulic computations for the proposed Boggy Swamp ditch:

TABLE 1.—*Data and computations for Boggy Swamp ditch.*

[Side slopes of ditch, ½ to 1.]

Stations.		Depth.	Bottom width.	Fall.		Computed velocity.	Watershed.		Computed ditch capacity.
From—	To—						Area.	Run-off.	
		Feet.	*Feet.*	*Ft. per foot.*	*Feet per mile.*	*Feet per second.*	*Acres.*	*Cu. ft. per sec.*	*Cu. ft. per sec.*
00	40	6	3	0.00225	11.88	.....	600	.....	.....
40	80	6	3	.00325	17.16	.....	1,150	.....	.....
80	130	6	3	.00206	10.88	3.6	1,800	.....	130
130	143	7	14	.00206	10.88	3.7	2,000	.....	700
143	260	7	14	.00051	2.69	2.9	3,300	.....	360
260	355	7	14	.00171	9.03	5.15	4,175	.....	630
355	423	7	14	.00171	9.03	5.15	8,000	.....	630
423	440	7	14	.00171	9.03	5.15	14,800	620	630
440	531	7	20	.00087	4.61	4.1	15,875	665	675
531	570	7	22	.00087	4.61	4.15	17,025	715	740
570	628	7	24	.00087	4.61	4.25	19,850	835	815
628	660	7	28	.00087	4.61	4.35	29,475	930	960
660	758	7	30	.00034	1.80	2.8	31,900	1,005	655

The estimate of the amount of excavation for this ditch was computed in 2,000-foot sections from the profile data secured. Six highway bridges will be required, three of 30 feet span, and one each of 15, 35, and 45 feet span.

Beaver Dam Branch No. 1 is the largest tributary of Boggy Swamp, being about 8 miles long. It has numerous tributaries, in which small ditches should be constructed. The swamp along this branch is very narrow, except the portion southwest of Scotia, which is about 2,000 feet wide, and formerly was cultivated in rice. The upper portion of the drainage area is rolling, and is practically all under cultivation except in the several bays. The lower part is much flatter and contains large areas of flat woods which are badly in need of drainage. The proposed improvements on Beaver Dam Branch No. 1 consist of a handmade ditch for the upper 7,550 feet, above the Seaboard Air Line Railway, and a minimum dredge ditch from the railroad down to Boggy Swamp, a total length of 38,500 feet. The fall is 37 feet in 7.3 miles, or 5 feet to the mile, but very little of it occurs in the upper mile. Two 30-foot highway bridges will be required.

Beaver Dam Branch No. 2 has a swamp that varies much in width, from 100 feet in some places to a half-mile in others. The watershed area comprises mostly good rolling land, much of which is under cultivation at the present time, although there is a large area of flat bays and ponds covered with a thick growth of timber. The proposed improvements consist of a minimum dredge ditch for its whole length of 25,420 feet, except the upper mile which should be a handmade ditch. The fall is about 35 feet in 5 miles. One 30-foot bridge will be required.

Manigault Branch heads in a series of flats and ponds between Shirley and Scotia, and joins Boggy Swamp where the swamps are subject to overflow from the Savannah River. For the first 2 miles, in the flats and ponds, the swamp is about one-fourth mile wide, but it narrows below the Augusta Road to about 100 feet, widening out again lower down to about 500 feet. The watershed area of Manigault Branch is for the most part fairly flat, with large stretches of flat pine woods and a small percentage of land under cultivation. The proposed improvements on this branch consist of a minimum dredge ditch 33,150 feet long. The fall in the upper 2 miles of the branch is slight, but below Augusta Road it is 44 feet in 3.6 miles. The lower mile of Manigault Branch is subject to overflow from the Savannah River, and while it is not absolutely necessary that the improvements extend down to Boggy Swamp, it is recommended that they be carried to that point, as this will provide a better outlet for the lands above. One 30-foot highway bridge will be needed.

Mill Branch Swamp, between the flat bay in which the branch rises and Haskell Baroney Swamp, averages hardly more than 100 feet wide.

The fall on this branch amounts to 38 feet in 4.8 miles, or about 8 feet to the mile. The watershed area is quite rolling, with marked differences in elevation between the highlands and the bays, and nearly all of the former are now under cultivation. The proposed improvements on this branch consist of a handmade ditch for the 6,700 feet above the Mill Road, and the minimum dredge ditch for the remainder of the 25,240 feet total length. Two 30-foot bridges will be required.

The Savannas lie in the flattest section of the district, nearest the Savannah River. The area drained, except that tributary to Rum Branch, is extremely flat for the most part, being composed almost entirely of flat swamp covered with an excellent growth of timber. The soil is very rich and could be converted into valuable farm land. The Savannas are several hundred feet wide, with no discernible channel or run. The vegetation in the upper part of this swamp is quite different from that in the other branches, for the others are covered with thick growths of timber and brush, while the Savannas are comparatively open, having a thick growth of grass and rushes about 3 feet high and only an occasional bush. The fall in the Savannas is only 6 feet in 3.8 miles. The proposed improvement consists of a dredge ditch of minimum section for the entire length of 19,950 feet. No new bridges will be needed.

To prevent the occasional overflow from the Savannah River, the breaks in the clay ridge on the west boundary of the district should be closed by low dikes. The amount and cost of this work has not been estimated.

Rum Branch drains an area consisting mostly of good rolling land now under cultivation, but including Rogers Bay and several other large bays. The upper end of the swamp along this branch is about 800 feet wide, but it soon narrows to about 100 feet, which width is maintained for about 2 miles; below this the width becomes very irregular. Neither the bays nor the lower end of the swamp is under cultivation. The fall of this branch is ample for its whole length, being 54.5 feet in 6.4 miles, or 8.5 feet to the mile. The proposed improvements consist of a handmade ditch for the upper 5,400 feet and a minimum dredge ditch through the remainder of the branch, which has a total length of 34,200 feet. Two new 30-foot bridges will be required.

Hurricane Branch drains about 1 square mile of fairly high and slightly rolling ground, practically all under cultivation. The swamp is very narrow the whole length of the branch. The fall amounts to 23.5 feet in 2.1 miles. There is at present a good ditch throughout the length of Hurricane Branch, 4 to 10 feet in top width, 3 to 4 feet in bottom width, and 2½ to 6 feet deep. This ditch has a good flow of water, but it could be improved by cleaning and straightening, which improvements are the only ones recommended on this branch. The length of the ditch is 11,150 feet.

IMPROVEMENTS IN BLACK SWAMP WATERSHED.

The watershed area of Black Swamp is comparatively flat, except the lower or southern portion, which is more rolling, with a good fall toward the swamp. A large part of the flat land is under cultivation, while the remainder is mostly flat bays and ponds with a thick covering of bushes and trees.

The swamp or wet land along this stream is 100 to 300 feet wide for the first few miles below the source, then 400 to 600 feet for a few miles, and finally reaches 800 to 1,000 feet width at the lower end. There is no well-defined channel, and during wet seasons the entire swamp is covered with water several feet deep. The growth in this swamp is a thick, tangled mass of vines, briars, canes, and bushes, with a fairly heavy growth of timber. The total fall is 79 feet, quite sufficient to give good drainage to these lands, and for the greater portion of the swamp it is quite uniform, as may be seen from the profile (fig. 3). It varies from 12.5 feet per mile at the upper end to 1.3 feet per mile for a short distance at the lower end.

The proposed improvements on Black Swamp consist, as shown in figures 2 and 3, of a dredge ditch starting at the Southern Railway just south of Furman and continuing down the swamp until overflow water from the Savannah River is encountered. This will require a ditch about 10 miles long. The depth should be 7 feet, with side slopes of ½ to 1. The ditch should start with a 14-foot bottom width, increasing to 30 feet. At the lower end the estimated capacity of the ditch is less than the calculated run-off, and consequently some flooding is to be expected. No harm will result from this, however, as the lower end of the swamp will be flooded by exteme high water in the Savannah River, and the lands bordering the swamp lie 15 to 20 feet above its level and have good natural drainage. The table below summarizes the data and computations for the Black Swamp ditch.

TABLE 2.—*Data and computations for Black Swamp ditch.*

(Side slopes of ditch, ½ to 1.)

Station.		Depth.	Bottom width.	Fall.		Computed velocity.	Watershed.		Computed ditch capacity.
From—	To—						Area.	Run-off.	
		Feet.	*Feet.*	*Feet per foot.*	*Feet per mile.*	*Feet per second.*	*Acres.*	*Cu. ft. per sec.*	*Cu. ft. per sec.*
00	80	7	14	0.00237	12.51	.....	2,000	.....	.....
80	102	7	14	.00200	10.56	.....	2,175	.....	.....
102	169	7	14	.00200	10.56	.....	3,575	.....	.....
169	180	7	14	.00200	10.56	.....	7,050	.....	.....
180	240	7	14	.00127	6.71	4.55	7,850	.....	555
240	299	7	14	.00127	6.71	4.55	10,775	453	555
299	320	7	14	.00127	6.71	4.55	12,600	529	555
320	339	7	16	.00095	5.02	4.1	12,960	542	560
339	407	7	20	.00095	5.02	4.3	16,650	700	710
407	432	7	22	.00095	5.02	4.35	17,425	732	775
432	460	7	22	.00095	5.02	4.35	17,925	753	775
460	526	7	30	.00023	1.31	2.4	18,500	777	565

The estimate of material to be excavated for this ditch was calculated in 2,000-foot sections, from the profile data. Three highway bridges will be required at the points where the proposed ditch crosses the public roads, one of 35 feet span and two of 30 feet.

Wolf Bay lies in the flat woods section of the district. Only a small part of the basin drained is under cultivation, the greater part being flats and bays covered with timber and brush. It has two forks, along both of which the swamp varies greatly in width but averages about 300 feet. The fall on this branch, from the head of the east fork, is about 35 feet in 4.6 miles. The proposed improvements on the east fork of this branch consist of a minimum dredge ditch for its entire length of 24,250 feet, except that the upper mile should be a handmade ditch, while the west fork should have a smaller ditch and is considered as lateral ditch No. 10. Four new bridges will be required, one span of 15 feet and three of 30 feet.

Causeys Branch has two outlets, part of the water going direct to Black Swamp through Shumans Bay and part flowing south through Titi Branch. Most of the drainage area is rolling land under cultivation. The swamp along Causeys Branch is quite narrow at the upper end, about 600 feet wide from the railway to Shumans Bay, where it widens to about 1,000 feet, then it rapidly narrows before reaching Black Swamp. The fall on the branch is comparatively large, 44 feet in 3.3 miles, or 13.3 feet to the mile. It is proposed to carry all the water by the more direct route through Shumans Bay, the improvement to consist of a handmade ditch throughout the entire length of 18,425 feet. Two new 15-foot bridges will be needed.

Titi Branch drains an area largely under cultivation, with rather rolling topography and a good fall from the adjoining lands to the branch. The swamp along this branch varies much in width, the upper end and middle section being wide, while the lower end is narrow. The fall on Titi Branch is quite large, amounting to 43 feet in 3 miles. The improvement proposed for this branch consists of a handmade ditch 16,275 feet long. One 15-foot bridge will be required.

Long Branch is the drainage outlet for a basin quite flat and covered with timber at the upper end, but a little more rolling and largely under cultivation at the lower end. The swamp along this branch averages about 200 feet in width, and it has a fall of about 28 feet in 3.2 miles. The proposed improvement consists of a handmade ditch through the entire branch, a distance of 17,900 feet. Three 15-foot bridges will be required.

Lyas Bay drains good, rolling land, a large part of which is now under cultivation. The swamp averages about 700 feet wide. The proposed improvement is a handmade ditch 9,900 feet long, running from the Southern Railway southwest to the bay, thence through it

to Black Swamp. The fall will be 22 feet in 1.9 miles. Two 15-foot bridges will be required.

Ballifore Branch heads in the flat woods southeast of Robertville. The watershed area is slightly rolling and is well under cultivation. The swamp averages about 100 feet wide, and the fall on the branch is 26 feet in 1.3 miles. The improvement proposed consists of a handmade ditch for the entire length of 7,000 feet. One 15-foot bridge will be required.

Rose Hill Branch drains an area that is fairly rolling, and a large part of which is cultivated. The swamp along this branch is rather wide at the upper end, but gradually decreases to not more than 50 feet at the lower end. The fall is about 16 feet to the mile. The proposed improvement is a handmade ditch for the entire length of 7,600 feet. One 15-foot bridge will be required.

IMPROVEMENTS IN INDEPENDENT WATERSHEDS.

Church Branch joins Black Swamp outside the drainage district. The upper end of the watershed area is quite flat and consists of open pine woods and grass, but the lower end is very rolling, with good natural drainage; nearly all of the land is under cultivation. The swamp along Church Branch is only 50 to 100 feet wide at the upper end, but it gradually increases until at the lower end it is about 500 feet wide. The fall on this branch amounts to 40 feet in 3.9 miles. The proposed improvement consists of a minimum dredge ditch 20,400 feet long. Five bridges of 30-foot span will be required.

Hog Branch joins King Branch and empties into the Pallachucolla Savannas, finally reaching Black Swamp lower down. The upper end of the watershed is very flat, composed almost entirely of flat woods, with occasional ponds and bays, all in timber. This section needs drainage outlets badly, as water stands several inches deep on it for long periods after heavy rains. The lower section of the watershed is more rolling, and fair natural drainage is secured by reason of a marked drop from the adjoining lands to the branch. A large portion of this section is under cultivation. The swamp along Hog Branch is very narrow at the upper end, but toward the lower end it widens to about 300 feet. The total fall on this branch is 46.5 feet in 6.1 miles, the slope increasing somewhat from the upper to the lower end. The proposed improvement consists of a ditch throughout Hog Branch and extending 2½ miles northward into the flat woods. The upper mile will be a handmade ditch, and the remainder a dredge ditch of minimum size, the total length being 32,150 feet. There is at present in the branch a small ditch in fair condition, but so small that it has not been considered in estimating the excavation. Two 30-foot bridges will be needed.

King Branch watershed consists of flat woods in the upper portion, and rolling land in the lower portion, which has fair natural drainage and is mostly under cultivation. The swamp along King Branch, like others in this part of the district, is narrow at the upper end and gradually widens toward the outlet. The fall is 40 feet in 5.6 miles, being greater at the lower end than at the upper. A minimum dredge ditch is recommended below the Orangeburg Road, and a handmade ditch extending north for about 1 mile into the flat woods to give those lands a drainage outlet. The ditch would have a total length of 29,490 feet. Two 30-foot bridges will be required.

Scott Swamp No. 1 drains rolling land principally, and most of the lower end of the area is cultivated. At the upper end the swamp is wide and flat, but it narrows rapidly toward the outlet. The fall is 39 feet in 2.4 miles. The proposed improvement is a handmade ditch 12,700 feet long. An existing small ditch about a mile long in the upper part of the swamp will reduce the necessary excavation by about 1,000 cubic yards. Two 15-foot bridges will be needed.

LATERAL DITCHES.

In addition to the ditches that have been described, practically all of which lie in the larger watercourses, 66 laterals should be constructed as indicated and numbered on the map (fig. 2). These will extend out from the main channels at all the low places, to provide drainage connection between the flat lands and the larger ditches. Owing to the lack of machinery suitable for constructing small ditches in wooded land, the laterals have been estimated as handmade ditches, 3 feet in bottom width, 5 feet deep, with ½ to 1 side slopes. The excavation has been computed as 1 cubic yard per linear foot of ditch. Where these laterals are crossed by public roads 23 bridges will be required, each 15 feet long. The following table shows the length and excavation for the lateral ditches:

TABLE 3.—*Length and excavation for lateral ditches.*

[Excavation=1 cubic yard per linear foot of ditch.]

Lateral No.	Tributary to—	Length and excavation.	Lateral No.	Tributary to—	Length and excavation.
		Ft. and cu. yds.			*Ft. and cu. yds.*
1	Boggy Swamp	3,600	16	Boggy Swamp	4,100
2	do	5,900	17	do	2,800
3	Beaver Dam No. 1	12,200	18	do	4,400
4	do	3,100	19	Beaver Dam No. 2	9,600
5	do	4,800	20	Rum Branch	3,300
6	do	12,300	21	do	4,700
7	Lateral No. 6	2,900	22	do	5,100
8	(Eliminated.)		23	Lateral No. 22	2,100
9	Beaver Dam No. 1	6,900	24	do	2,200
10	Wolf Bay	6,875	25	Lateral No. 26	3,600
11	Black Swamp	4,100	26	Rum Branch	11,650
12	do	5,300	27	do	7,800
13	Church Branch	8,400	28	The Savannas	7,700
14	Beaver Dam No. 1	4,500	29	Rum Branch	6,900
15	Beaver Dam No. 2	5,300	30	Mill Branch	6,600

TABLE 3.—*Length and excavation for lateral ditches*—Continued.

Lateral No.	Tributary to—	Length and excavation.	Lateral No.	Tributary to—	Length and excavation.
		Ft. and cu. yds.			*Ft. and cu. yds.*
31	The Savannas	7,200	51	Black Swamp	2,800
32	Boggy Swamp	4,700	52	Independent	3,900
33	do	5,150	53	do	8,000
34	do	15,200	54	Titi Branch	2,500
35	Manigault Branch	8,800	55	Beaver Dam No. 1	4,200
36	King Branch	3,900	56	Wolf Bay	3,200
37	Manigault Branch	7,000	57	Black Swamp	4,000
38	Independent	5,400	58	Hog Branch	3,000
39	Causeys Branch	3,900	59	Lateral No. 30	8,300
40	Titi Branch	7,200	60	Manigault Branch	5,850
41	Black Swamp	5,200	61	Lateral No. 37	3,000
42	do	4,900	62	Lateral No. 38	3,900
43	do	7,200	63	do	2,750
44	Long Branch	4,900	64	Boggy Swamp	6,000
45	Black Swamp	8,300	65	Lateral No. 64	1,300
46	do	7,050	66	Mill Branch	2,300
47	Lateral No. 46	2,900	67	Black Swamp	2,950
48	Black Swamp	2,900			
49	Church Branch	8,000		Total	359,475
50	Lateral No. 49	3,000			

ESTIMATE OF COST.

Owing to the arrangement of the swamps and branches in Black and Boggy Swamps drainage district the excavation will necessarily be slow, as the dredges will have to be rebuilt several times. The cost of excavation by dredge in the two main swamps has been estimated at 8 cents per cubic yard and in the tributaries at 10 cents per cubic yard. These figures are based on contracts in different localities, where conditions are similar to those in this district. The handwork has been estimated at 25 cents per cubic yard. The cost of clearing the right of way is included in the unit price for excavation; the purchase cost has been estimated at $10 per acre. Bridges have been estimated at $20 per foot of span, plus $200. A summarized estimate of the costs for the whole district is given in the following table:

TABLE 4.—*Summary of cost data.*

BOGGY SWAMP WATERSHED.

Ditch.	Excavation.				Bridges.	Right of way, at $10 per acre.	Engineering and legal, at 10 per cent.	Total.
	Cubic yards, at 8 cents.	Cubic yards, at 10 cents.	Cubic yards, at 25 cents.	Cost.				
Boggy Swamp	369,540		9,440	$31,923	$4,900	$1,430	$3,825	$42,078
Beaver Dam No. 1		140,510	7,550	15,939	1,600	620	1,816	19,975
Beaver Dam No. 2		91,440	5,280	10,464	800	410	1,167	12,841
Manigault Branch		150,560		15,050	800	610	1,646	18,106
Mill Branch		84,170	6,700	10,092	1,600	390	1,208	13,290
The Savannas		90,570		9,057		370	943	10,370
Rum Branch		130,750	5,400	14,425	1,600	570	1,660	18,255
Hurricane Branch	(Cleaning and straightening.)			1,050		80	113	1,243
Laterals (38)			223,050	55,762	5,500	1,540	6,280	69,082
Total for Boggy Swamp watershed				163,762	16,800	6,020	18,658	205,240

TABLE 4.—*Summary of cost data*—Continued.

BLACK SWAMP WATERSHED.

Ditch.	Excavation.				Bridges.	Right of way, at $10 per acre.	Engineering and legal, at 10 per cent.	Total.
	Cubic yards, at 8 cents.	Cubic yards, at 10 cents.	Cubic yards, at 25 cents.	Cost.				
Black Swamp	261,170			$20,894	$2,500	$1,070	$2,446	$26,910
Wolf Bay		86,120	5,280	9,932	2,900	390	1,322	14,544
Causeys Branch			18,425	4,606	1,000	130	574	6,310
Titi Branch			16,275	4,069	500	110	468	5,147
Long Branch			17,900	4,475	1,500	120	610	6,705
Lyas Bay			9,900	2,475	1,000	70	355	3,900
Ballifore Branch			7,000	1,750	500	50	230	2,530
Rose Hill Branch			7,600	1,900	500	50	245	2,695
Laterals (18)			86,175	21,544	5,000	590	2,713	29,847
Total for Black Swamp watershed				71,645	15,400	2,580	8,963	98,588
INDEPENDENT WATERSHEDS.								
Church Branch		92,620		$9,262	$4,000	$380	$1,364	$15,006
Hog Branch		121,990	5,280	13,519	1,600	530	1,565	17,214
King Branch		109,910	5,280	12,311	1,600	480	1,439	15,830
Scott Swamp No. 1			11,700	2,925	1,000	90	402	4,417
Laterals (10)			50,250	12,562	1,000	350	1,391	15,303
Total for independent watersheds				50,579	9,200	1,830	6,161	67,770

Total for the drainage district, $371,598.
Number of acres in district, 67,642.
Average cost per acre, $5.50.

The total cost of the 66 lateral ditches has been estimated above as $114,232. Omitting these, the cost of ditching only the two main swamps and the principal tributaries would be, as estimated, $257,366, or $3.80 per acre. It is strongly recommended, however, that the laterals be constructed, as well as the main ditches.

MAINTENANCE.

Not much work should be required to keep the ditches in condition after they are constructed. The velocity of flow due to large fall in most of the ditches will assist materially in keeping down the growth of vegetation in the channels. However, an organized method of inspection should be adopted in the district whereby each ditch will be examined at least once each year, preferably just before the rainy season. Any obstructions should be removed and any damage to the ditches should be repaired as soon as noted. If maintenance work is given prompt attention, the defects can be remedied with comparatively little expense; but if it is neglected, the task will become a formidable one, and in the meantime the efficiency of the drainage system will be reduced.

CONCLUSIONS.

Anyone who is at all familiar with the agricultural conditions existing in the Black and Boggy Swamps drainage district at the time this survey was made, could not but be impressed with the need for artificial drainage. Large areas of land are at present yielding no revenue whatever, yet all apparently have such natural qualities as would make them excellent farming lands if they could be relieved of excess water. The plans presented in this report provide for such relief, which should be secured at an average cost of about $5.50 per acre and would be worth many times that amount, although to realize the fullest possibilities of the soil in many parts of the district tile drainage also should be installed. The ditches have been designed of ample depth to serve as outlets for the tile drains.

Besides the financial advantage of increased crop production due to drainage, there is the benefit to the general health of the community, which is none the less real and important because it is less easily measured in money values. The decrease of malaria, which now exists in certain parts of the district, by removing the breeding places of mosquitoes, will make those parts more desirable for residence and thereby add to their commercial value.

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